



# Florida Department of Environmental Protection

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## REQUEST FOR ADDITIONAL INFORMATION

September 7, 2017

Mr. Conrad Webley, Director of Health, Safety and Environmental  
Chemring Ordnance, Inc.  
10625 Puckett Road  
Perry, FL 32348  
[cwebley@chemringordnance.com](mailto:cwebley@chemringordnance.com)

Re: **First Request for Additional Information (RAI)**  
**August 30, 2017 Meeting Summary**  
Taylor County – Hazardous Waste  
Chemring Ordnance, Inc. (COR)  
Facility ID: FLD 047 966 593  
DEP Application No.: 160990-013-HO

Dear Mr. Webley:

Thank you for your application for an Operating Permit for the above referenced Facility. The Department has assigned DEP Application No. 160990-013-HO to the application. A Department staff review of the application and supporting documentation submitted on August 03, 2017, indicates the application is incomplete. Pursuant to the provisions of Rule 62-730.220 F.A.C. and Rule 62-730.220(6), F.A.C., please provide the information listed below and in the attached document. Please refer to this correspondence in your response. The application will remain incomplete until receipt of the requested information. The response to this correspondence must be signed, sealed, and dated by a registered Florida Professional Geologist.

Specific comments are enclosed; however, the Department would like to highlight the following concerns:

1. Closure Plan: The submitted Closure Plan covers the necessary elements except for those outlined below, but would benefit from a little more detail and tightening of the language. The plan, which includes a targeted groundwater sampling event at closure, states that Chemring Ordnance, Inc. (COR) will perform the sampling. A Closure Plan, and hence cost estimates, must be based on the cost to the owner or operator of hiring a third party to perform the closure (removal, disposal, decontamination, sampling, certification, etc.) per 40 CFR 264.142(a)(2). All sampling mentioned in the plan must be performed, and estimated to be performed, by a third-party. The cost estimates appear to include third party costs but the language of the plan does not reflect that. Additionally, on-site disposal (i.e., burning of

accumulated wastes) is acceptable if the facility can demonstrate that the capacity to do so will exist at the time of closure. This demonstration needs to be stated and supported in the plan. The language of the Closure Plan should be appropriately revised.

According to the submitted Closure Plan, sampling closure activities are contingent on the results of the current and proposed soil and groundwater detection monitoring to be conducted over the lifetimes of the OBU and ODU, respectively. Therefore, language should be added to the Closure Plan to indicate that the plan will be revised if any new soil and/or groundwater information becomes known that affects the scope of the Closure Plan. The plan should also be reviewed and revised 60 days prior to closure. Upon renewal or issuance of the permit modification, a permit condition addressing this issue will be added to the permit.

2. Cost Estimates: Chemring has significantly revised closure cost estimates from \$674,867 to \$319,971.51. According to the submitted Closure Plan, Chemring anticipates a clean closure of the Open Burn Unit (OBU) and Open Detonation Unit (ODU), eliminating the need for post-closure care costs. The Closure Plan assumes that one round of decontamination of the OBU will be adequate and minimal soil excavation will be needed near the OBU with more extensive soil removal at the ODU. These assumptions are acceptable; however, the Department has some concerns with the Environmental Monitoring Plan as outlined below. Further, Closure Cost Estimates anticipate that no groundwater remediation will be necessary to clean close the site. In order to clean close a facility under Rule 62-780, F.A.C. (RMO-I option), no contamination may remain at concentration levels above the appropriate cleanup target levels (CTLs) in any media at the facility. Contaminant of Concern (COC) Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) has been found above groundwater cleanup target levels (GCTLs) in the groundwater near the OBU (September 2016). How will Chemring address this contaminant at closure if not through a remedial action? Please provide a detailed description of how the facility will address known contamination in the groundwater and include a revised cost estimate.
3. Environmental Monitoring Plan: The Environmental Monitoring Plan (EMP) addresses soil and groundwater separately and includes tables listing the contaminants (metals and energetics) to be analyzed during sampling events. Metals are analyzed each event, but energetics appear to be analyzed only if certain conditions are triggered (groundwater) or every 5 years (soil).
  - a. Analytical Lists: The current plan includes both a Suite A and Suite B analytical list of contaminants. The selection of the list differs depending on whether the purpose of the sampling is for assessment (Suite A) or detection (Suite B) purposes. Currently, only the assessment list (Suite A) contains energetics and is performed less often. As discussed during our meeting on August 30<sup>th</sup>, 2017, the use of two lists during the facility's operational phase is confusing. Please consider combining these lists into a single list for simplicity. The new list should contain energetics for each sampling event in both soil and groundwater. A separate, more comprehensive list could be submitted in the closure plan if desired. Note: based on past events, additional

sampling and analysis may be performed at the discretion of the facility's professional geologist; however, this should be clearly stated in the plan. Additional soil and groundwater concerns are discussed in detail below.

b. Soil:

- i. Sampling Methodology: Energetics like RDX are often deposited in the soil as discrete particles with strongly heterogeneous areal distributions (please see Attachment B - EPA Technical Fact Sheet). The Department is concerned that the soil sampling method proposed in the EMP for detection monitoring (limited discrete soil sampling on a grid pattern) may lead to highly variable soil data and more importantly, a possible mischaracterization or complete omission, of evidence of any contamination in the soil. Because of this, EPA recommends, and the Department concurs with, the use of an incremental field sampling approach. The grid approach proposed in the plan is a good step toward that, but the Department would like to see a more robust, detailed sampling grid based on the ITRC's incremental sampling methodology (ISM) (please see ITRC's ISM Guidance at <http://www.itrcweb.org/ism-1/>). Please note that for assessment/delineation and closure requirements under Rule 62-780, F.A.C., discrete soil sampling should be performed. That discrete soil sampling should be compared to residential CTLs for clean closure. Thus, the Closure Plan must include discrete soil sampling, but the EMP should consider ISM sampling due to the characteristics of energetics.
- ii. Sampling Depths: The current EMP includes sampling of surficial soils at depths of 0" to 6". Energetics at OBUs are likely to be found within the surficial layers (0 to 18 inches) of soil, for assessment/delineation and closure purposes for both the OBU and ODU, the Department requires soil sampling be performed from 0 to 6 inches below land surface, 6" to 24", and so on until the water table is reached. Surficial soil sampling will not provide a complete picture of soil contamination at these units and will be inadequate for closure. For detection monitoring at the OBU, please add the 6" to 24" interval for soil sampling events. Please review and revise the soil sampling portion of the Closure Plan and the EMP accordingly.
- iii. Sampling Frequency: Based on the footnotes of the tables mentioned in the Environmental Monitoring Plan (Table II.M.5-1 and Table II.M.5-2), the soil sampling parameters for the semi-annual soil sampling events from July 2017 to January 2020 will be for metals only. Energetics RDX, HMX and perchlorate will be sampled next in July 2020. Please revise the footnotes and sampling frequencies based on other comments.

- b. Groundwater: The EMP addresses sampling and analysis for both metals and energetics in groundwater at the facility. The footnotes to the groundwater table in the EMP (Table II.M.6-1), however, state that energetics RDX and HMX will only be monitored in groundwater if they are detected in the soil above the soil cleanup target levels (SCTLs). It is not clear whether the plan refers to the residential or industrial

SCTLs, but it appears to imply the industrial SCTLs. In the case of energetics, neither residential nor industrial CTLs are appropriate as a determining factor. One of the characteristics of RDX is that it quickly mobilizes from soil to groundwater. The leachability standard for RDX in Florida is 0.002 mg/kg; its low number again indicates that this contaminant readily leaches to the groundwater. Based on this characteristic, RDX even in low concentrations may cause groundwater contamination. Thus, leachability standards should be used instead of residential or industrial SCTLs. Unfortunately, review of previously submitted laboratory data for this facility shows that the maximum detection limit (MDL) of RDX in soil is 0.062 mg/kg (July 2015 Soil Sampling) which does not appear to be adequate to compare with the leachability standards (i.e., MDL > 0.002 mg/kg). By making your groundwater sampling contingent on the soil data, you are likely missing valuable groundwater data. Energetics RDX, HMX, and perchlorate should be monitored much more frequently in groundwater near the OBU and ODU. Further, if the soil sampling is possibly not detecting contamination due to the sampling methods, groundwater data is key to determining if contamination is occurring at the facility and thus, energetics in groundwater should be analyzed far more regularly.

Closure requirements dictate that all Contaminants of Concern (COCs) are sampled and analyzed for at closure. The costs for energetics sampling/analysis in both soil and groundwater appear to have been omitted in the submitted documents. The Closure Plan and Closure Cost Estimates for the OBU and ODU must be revised to incorporate the sampling and analysis for energetics, along with metals, identified as COCs in the current permit.

- c. The Department recommends that a meeting be held to review and revise the current soil and groundwater monitoring plans, especially in regard to the concerns noted above.
4. Alternatives to ODU: Please present a discussion of alternatives that may be used at your facility in lieu of a permitted ODU. Please also provide a cost-benefit analysis concerning the use of an on-site ODU versus the off-site disposal method currently used.

In order for the Department to continue processing your application, please submit the requested information as soon as possible. The Department must receive a response within 30 days of receipt of this letter, October 7, 2017, unless a written request for additional time to provide the requested information is submitted and approved. Pursuant to Rule 62-730.220(6), F.A.C., and Section 120.60, Florida Statutes, failure of an applicant to provide the timely requested information by the applicable deadline may result in denial of the application. You are encouraged to contact this office to discuss the items requested to assist you in developing a complete and adequate response.

Please submit the response in electronic format to [HWPP@dep.state.fl.us](mailto:HWPP@dep.state.fl.us), with a copy to [Dawn.Cinquino@dep.state.fl.us](mailto:Dawn.Cinquino@dep.state.fl.us). If the file is very large, you may post it to a folder on this office's ftp site at: <ftp://ftp.dep.state.fl.us/pub/incoming/DWM/>. After posting the document,

Mr. Webley  
September 7, 2017  
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please send an e-mail to [HWPP@dep.state.fl.us](mailto:HWPP@dep.state.fl.us), with a copy to [Dawn.Cinquino@dep.state.fl.us](mailto:Dawn.Cinquino@dep.state.fl.us), alerting us that it has been posted.

Should you have any questions, please contact me at (850) 245-8766 or via email at [Dawn.Cinquino@dep.state.fl.us](mailto:Dawn.Cinquino@dep.state.fl.us).

Sincerely,



Bryan Baker, P.G.  
Environmental Administrator  
Florida Department of Environmental Protection

BB/dc

Enclosures:

Attachment A - List of Requested Information  
Attachment B – EPA Technical Fact Sheet

cc (with enclosures):

Brian Bastek, USEPA Region 4, [bastek.brian@epa.gov](mailto:bastek.brian@epa.gov)  
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## **Attachment A - List of Requested Information**

Facility Name: Chemring Ordnance, Inc. (COR)  
Facility ID: FLD 047 966 593  
DEP Application No.: 160990-013-HO

1. **Part I, General Facility Information:**

- a. Page 3 of 4: The name of the engineer for this permit modification application is left blank; however, in Part II Specific Facility Information (page 3 of 4), a “Lisa Jo Baker” has signed and stamped. Please include the engineer’s name on the Part I portion of the application and submit the revised page electronically for our records.

2. **Part II.I, Subpart X: Miscellaneous Units:**

a. **Part II-I-A:**

i. **Part II-I-A-3b, Description of OD Unit:**

1. Page 3: In the line above the table, the sentence reads, “Each quadrant of the ODU...” The term quadrant implies four parts to an item. The Department understands that this wording was inadvertently left when the ODU design was changed from four pits to one. Please confirm, revise the page as appropriate and submit the revised page electronically for our records.

ii. **Part II-I-A-3c, General OD Management Practices:**

1. Page 4, Pre-Detonation Requirements: A relative humidity of greater than 30% is listed as part of the pre-detonation requirements. In the Product Work Instructions (in Part II-A, Contingency Plan) on page 3 of 7, a humidity of greater than 35% is noted. Please explain, revise as appropriate, and submit the revised pages electronically for our records.
2. Page 5, Detonation Management Practices:
- a. Bullets 6 through 8 mention multiple units/pits. The Department understands that this wording was inadvertently left when the ODU design was changed from four pits to one. Please confirm, revise the page as appropriate and submit the revised page electronically for our records.
- b. How many personnel will be on-site during the detonation process? Is there a minimum number for safety purposes?

b. **Part II-X-C, Air Quality Assessments:**

- i. Operation Limits: The Department would like to see the ODU and OBU operations restricted to different days in order to reduce air emission concerns.

c. **Part II-X-F, Additional Information:**

- i. F-1d, Table Overpressure in dB: Based on this table and OSHA guidelines which requires ear protection over 115dB, if a NEW of 300lbs is detonated, ear protection should be used within 4,750 feet of the pit; within 3,250 feet of the pit if 100 lbs. NEW is detonated. This appears to include portions of the manufacturing plant. The Department understands from information provided during the August 30<sup>th</sup> meeting that this table is based on very limited data

and extrapolated out. If the ODU is permitted, upon the collection of an adequate data set from on-site operations of the ODU (no more than 2 years of data), please revise this table and resubmit for our records.

- ii. Figure II-I-F-1, Airblast-Ground Vibration Study Locations: Is the test range identified correctly on this figure?

### **3. Attachment II-K-1, Closure Plan and Closure Cost Estimates Attachments**

#### **a. A2-1, Closure Plan:**

- i. Pages 2 to 3, A2-1f, Procedures for Decontamination and/or Disposal:

##### **1. OBU Soils:**

- a. For the OBU, soils will be collected from a 6-foot depth. Why was this sampling depth selected? For assessment/delineation and closure procedures, Rule 62-780, F.A.C. requires discrete soil samples from 0-6 inches, 6" to 2', and two-foot intervals afterwards down to the depth of the water table. Please explain the reasoning behind the soil depth selection and revise the Closure Plan as necessary.
- b. The last line in the OBU soils section indicates that a form of institutional control will be implemented during the post-closure care period. Please explain in more detail as it is the Department's understanding that there will be no post-closure care period unless clean closure cannot be achieved.

- 2. ODU Groundwater: What is the depth to groundwater at the ODU location? Will the base of the pit or soil samples taken one foot below it will intersect the groundwater?

#### **b. A2-11, Closure Cost Estimate:**

- i. ODU-3, Removal of Soil: Closure Cost Estimates include the cost to remove impacted soil; but do not appear to include the cost to dispose of this soil. Please explain and revise as appropriate.

### **4. Attachment II-M, Environmental Monitoring Plan:**

#### **a. C - Soil Monitoring Plan:**

- i. Page 10, Monitoring Parameters: Please provide additional information about, and explain the reasoning behind, the selection of the energetics and metals that are sampled for.
- ii. Page 11, Cleanup Target Levels: The plan states that action levels will be set at 80% of residential SCTLs; however, Table M-5-3 shows action levels based on commercial CTLs. Several of the last soil sampling reports also show commercial CTL-based action levels. Please explain or revise and resubmit the appropriate pages.
- iii. Page 11, Sample Frequency: The EMP states that soil sampling will be performed every January and July of each year. Please include the month when the report for each sampling event will be submitted (i.e., February/August or March/September).
- iv. Page 15, Table M-5-3: Please add the identifier "I" before "SCTL" in the SCTL column header to identify these numbers as industrial/commercial cleanup target level numbers. If this table is revised based on the previous

comment, please use the R-SCTL label. Please revise the action levels per the previous comment.

b. **D – Groundwater Monitoring Plan:**

i. **Page 18, D-2, Description of the Groundwater Monitoring System:**

1. Deeper wells (AW-3, AW-4, and AW-5) exist near the OBU to monitor the groundwater at deeper depths; however, only shallow wells exist near the proposed ODU. If permitted, a deeper well will be required at the ODU.
2. This section mentions “background wells”. It is the Department’s understanding that there is only one background well for the OBU and ODU units, PC-4. Please confirm and review this well’s adequacy for determining background concentrations. Are there any other wells that may be used for this purpose? Is background well PC-4 of a sufficient depth?



# Technical Fact Sheet – Hexahydro-1,3,5-trinitro- 1,3,5-triazine (RDX)

January 2014



## TECHNICAL FACT SHEET – RDX

### At a Glance

- ❖ Highly explosive, white crystalline solid.
- ❖ Synthetic product that does not occur naturally in the environment.
- ❖ Has been used extensively in the manufacture of munitions and accounts for a large part of the explosives contamination at active and former U.S. military installations.
- ❖ Not significantly retained by most soils and biodegrades very slowly under aerobic conditions. As a result, it can easily migrate to groundwater.
- ❖ Not expected to persist for a long period of time in surface waters because of transformation processes.
- ❖ Classified as a Group C (possible human) carcinogen.
- ❖ Can damage the nervous system if inhaled or ingested.
- ❖ EPA plans to update its toxicity benchmarks and health risk assessment.
- ❖ Basic types of field screening methods include colorimetric and EXPRAY.
- ❖ Primary laboratory analytical methods include liquid and gas chromatography.
- ❖ Potential treatment technologies include in situ bioremediation, granular activated carbon treatment, composting, phytoremediation and incineration.

### Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), including its physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet is intended for use by site managers and field personnel who may address RDX contamination at cleanup sites or in drinking water supplies.

RDX is a secondary explosive<sup>1</sup> that is used extensively by the U.S. military in manufacturing explosives. Major manufacturing of RDX began in the United States in 1943 during World War II; RDX was produced in enormous quantities at the Government Owned-Contractor Operated (GOCO) Holston Army Ammunition Plant (AAP) in Kingsport, Tennessee, for use in military munitions in World War II and afterwards (U.S. AEHA 1985).

During the 1940s through the 1970s, Department of Defense (DoD) ammunition plants and depots demilitarized off-specification, unserviceable and obsolete munitions using steam-out and melt-out processes to recover 2,4,6-trinitrotoluene (TNT) and TNT-containing explosive fillers such as Composition B (TNT/RDX mixture). These processes often generated significant quantities of explosives-contaminated wastewater. The untreated wastewater was discharged into unlined impoundments, lagoons, ditches and playas, which resulted in significant levels of soil and groundwater contamination. Groundwater contamination from RDX was first reported in the late 1980s (Spalding and Fulton 1988).

RDX is still widely used in U.S. military munitions and is present in munitions fillers such as Composition A, Composition B, Composition C and Cyclotols. With its manufacturing impurities and environmental transformation products, this compound accounts for a large part of the explosives contamination at active and former U.S. military installations (EPA 1999).

<sup>1</sup>Secondary explosives are bursting and boosting explosives (used as the main bursting charge or as the booster that sets off the main bursting charge) (USACE 2005).

## What is RDX?

- ❖ RDX, also known as Royal Demolition Explosive, cyclonite, hexogen and T4, is a synthetic product that does not occur naturally in the environment and belongs to a class of compounds known as explosive nitramines (ATSDR 2012; CRREL 2006).
- ❖ Production of RDX in the United States has been limited to Army ammunition plants. It is currently manufactured at one facility in the United States, the GOCO Holston AAP in Kingsport, Tennessee (which has operated since 1943) (ATSDR 2012; HSDB 2013; U.S. AEHA 1985).
- ❖ RDX is not produced commercially in the United States; however, RDX is used both in military and commercial applications. Some U.S. companies import RDX from outside the United States for use in some commercial applications (ATSDR 2012; EPA 2010).
- ❖ RDX is one of the most powerful high explosives available and was widely used during World War II. It is present in more than 4,000 military items, from large bombs to very small igniters (DoD 2011).
- ❖ It is a highly explosive, white crystalline solid (in its pure form) that is often mixed with other explosives, oils or waxes to make military munitions and other products (DoD 2011).
- ❖ It is commonly used as an ingredient in plastic explosives and has been used as explosive “fill” in most types of munitions compounds (DoD 2011; MMR 2001).
- ❖ RDX can be used alone as a base charge for detonators or mixed with other explosives such as TNT to form Cyclotols, which produce a bursting charge for aerial bombs, mines and torpedoes (ATSDR 2012; Lewis 2000).
- ❖ RDX is commonly found at hand grenade ranges, antitank rocket ranges, bombing ranges, artillery ranges, munitions testing sites, explosives washout lagoons, demolition areas and open burn/open detonation (OB/OD) sites (CRREL 2006, 2007; EPA 2005, 2012d).

### Exhibit 1: Physical and Chemical Properties of RDX (ATSDR 2012; HSDB 2013; Major and others 2007)

Property	Value
Chemical Abstracts Service (CAS) Number	121-82-4
Physical Description (physical state at room temperature)	White Crystalline Solid
Molecular weight (g/mol)	222.26
Water solubility at 25°C (mg/L)	59.7
Octanol-water partition coefficient (Log K <sub>ow</sub> )	0.87
Soil organic carbon-water coefficient (Log K <sub>oc</sub> )	1.80
Boiling point (°C)	Decomposes
Melting point (°C)	204 to 206
Vapor pressure at 20°C (mm Hg)	1.0 x 10 <sup>-9</sup> (ATSDR 2012); 4.0 x 10 <sup>-9</sup> (HSDB 2013)
Specific gravity at 20 °C (g/mL)	1.82
Henry's Law Constant at 25°C (atm-m <sup>3</sup> /mol)	2.0 x 10 <sup>-11</sup>

Abbreviations: g/mol – grams per mole; mg/L – milligrams per liter; °C – degrees Celsius; mm Hg – millimeters of mercury; g/mL – grams per milliliter; atm-m<sup>3</sup>/mol – atmosphere - cubic meters per mole.

## What are the environmental impacts of RDX?

- ❖ RDX can be released to the environment through spills, firing of munitions, disposal of ordnance, open incineration and detonation of ordnance, leaching from inadequately sealed impoundments and demilitarization of munitions. The compounds can also be released from manufacturing and munitions processing facilities (ATSDR 2012).
- ❖ As of 2007, RDX had been identified at more than 30 sites on the EPA National Priorities List (NPL) (HazDat 2007).
- ❖ In the atmosphere, RDX is expected to exist in the particulate phase and settles by wet or dry deposition (ATSDR 2012; HSDB 2013).

## What are the environmental impacts of RDX? (continued)

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- ❖ Low soil sorption coefficient ( $K_{oc}$ ) values indicate that RDX is not significantly retained by most soils and can migrate to groundwater. However, the rate of migration depends on the composition of the soil (ATSDR 2012; EPA 2005).
- ❖ RDX can migrate through the vadose zone and contaminate underlying groundwater aquifers, especially at source areas that have permeable soils, a shallow groundwater table and abundant rainfall (CRREL 2006; EPA 2012d).
- ❖ RDX dissolves slowly in water because of its slow rate of dissolution from the solid phase and does not evaporate from water readily as a result of its low vapor pressure (CRREL 2006; EPA 2005).
- ❖ Phototransformation of RDX in soil is not significant; however, it is the primary physical mechanism that degrades RDX in aqueous solutions. Consequently, RDX is not expected to persist for a long period of time in surface waters (ATSDR 2012; CRREL 2006; HSDB 2013).
- ❖ Based on its low octanol-water partition coefficient ( $K_{ow}$ ) and low experimental bioconcentration factor, RDX has a low bioconcentration potential in aquatic organisms (ATSDR 2012; EPA 2005).
- ❖ Results from a study indicate that RDX may bioaccumulate in plants and could be a potential exposure route to herbivorous wildlife (CRREL 2006; EPA 2005; Harvey and others 1991).

## What are the routes of exposure and the health effects of RDX?

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- ❖ Potential exposure to RDX could occur by dermal contact or inhalation exposure; however, the most likely route of exposure at or near hazardous waste sites is ingestion of contaminated drinking water or agricultural crops irrigated with contaminated water (ATSDR 2012).
- ❖ The EPA has assigned RDX a weight-of-evidence carcinogenic classification of C (possible human carcinogen) based on the presence of hepatocellular adenomas and carcinomas in female mice that were exposed to RDX (EPA IRIS 1993).
- ❖ The American Conference of Governmental Industrial Hygienists (ACGIH) has classified RDX as a Group A4, not classifiable as a human carcinogen (ACGIH 2011).
- ❖ RDX targets the nervous system and can cause seizures in humans and animals when large amounts are inhaled or ingested. Human studies also revealed nausea and vomiting after inhalation or oral exposure to unknown levels of RDX (EPA 2005; HSDB 2013; Ketel and Hughes 1972).
- ❖ Potential symptoms of overexposure include eye and skin irritation, headache, irritability, fatigue, tremor, nausea, dizziness, vomiting, insomnia and convulsions (HSDB 2013; NIOSH 2010).
- ❖ Animal studies found that the ingestion of RDX for 3 months or longer resulted in decreased body weight and slight liver and kidney damage in rats and mice (ATSDR 2012).
- ❖ EPA plans to update its toxicity benchmarks and health risk assessment for RDX in its database of chemical risk values, the Integrated Risk Information System (IRIS). RDX was included as part of EPA's 2012 IRIS agenda and the assessment is under way (EPA 2012c).
- ❖ Limited information is available regarding the effects of long-term, low-level exposure to RDX (ATSDR 2012).

## Are there any federal and state guidelines and health standards for RDX?

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- ❖ EPA assigned RDX a chronic oral reference dose (RfD) of  $3 \times 10^{-3}$  milligrams per kilogram per day (mg/kg/day) (EPA IRIS 1993).
- ❖ The Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.2 mg/kg/day for acute-duration oral exposure (14 days or less), 0.1 mg/kg/day for intermediate-duration oral exposure (15 to 364 days) and 0.1 mg/kg/day for chronic-duration oral exposure (365 days or more) to RDX (ATSDR 2012).
- ❖ The EPA has assigned an oral slope factor for carcinogenic risk of 0.11 mg/kg/day, and the drinking water unit risk is  $3.1 \times 10^{-6}$  micrograms per liter ( $\mu\text{g/L}$ ) (EPA IRIS 1993).
- ❖ EPA risk assessments indicate that the drinking water concentration representing a  $1 \times 10^{-6}$  cancer risk level for RDX is 0.3  $\mu\text{g/L}$  (EPA IRIS 1993).

## Are there any federal and state guidelines and health standards for RDX? (continued)

- ❖ The EPA has established drinking water health advisories for RDX, which are drinking water-specific risk level concentrations for cancer ( $10^{-4}$  cancer risk) and concentrations of drinking water contaminants at which noncancer adverse health effects are not anticipated to occur over specific exposure durations (EPA 2012a).
  - \* The EPA has established a lifetime health advisory guidance level of 0.002 milligrams per liter (mg/L) for RDX in drinking water. The health advisory for a cancer risk of  $10^{-4}$  is 0.03 mg/L.
  - \* EPA also established a 1-day and 10-day health advisory of 0.1 mg/L for RDX in drinking water for a 10-kilogram child.
- ❖ For RDX in tap water, EPA has calculated a screening level of 0.61  $\mu\text{g/L}$  (EPA 2013).<sup>1, 2</sup>
- ❖ EPA has calculated a residential soil screening level (SSL) of 5.6 milligrams per kilogram (mg/kg) and an industrial SSL of 24 mg/kg. The soil-to-groundwater risk-based SSL is  $2.3 \times 10^{-4}$  mg/kg (EPA 2013).
- ❖ EPA has not established an ambient air level standard or screening level for RDX (EPA 2013).
- ❖ EPA included RDX on the third Contaminant Candidate List, which is a list of unregulated contaminants that are known to or may occur in drinking water and may require regulation under the Safe Drinking Water Act (EPA 2012b).
- ❖ The National Institute for Occupational Safety and Health (NIOSH) established a recommended exposure limit of 1.5 milligrams per cubic meter ( $\text{mg/m}^3$ ) as the time-weighted average (TWA) over a 10-hour work exposure and  $3 \text{ mg/m}^3$  as the 15-minute, short-term exposure limit for airborne exposure to RDX (NIOSH 2010).
- ❖ The ACGIH has set a threshold limit value of  $0.5 \text{ mg/m}^3$  as the TWA over an 8-hour work exposure for airborne exposure to RDX (ACGIH 2011).
- ❖ Numerous states have established regulations on explosives for air quality control, solid waste disposal, storage, manufacture and use. Regulatory agencies in states such as Colorado and New York have specified RDX cleanup levels for water of less than 1 part per billion (ppb) (DoD ESTCP 2008).
- ❖ Massachusetts has established a reportable concentration of 0.001 mg/L for the GW-1 category (based on the use of groundwater as drinking water) and 50 mg/L for the GW-2 category (based on the potential for volatile material to migrate into indoor air). For soil, Massachusetts established a reportable concentration of 1 mg/kg for the S-1 category (based on sensitive uses of the property and accessible soil) and 60 mg/kg for the S-2 category (based on property uses associated with moderate exposure and accessible soil) (Mass DEP 2008).
- ❖ The Department of Transportation has many regulations on the transportation of RDX (DOT 1989).

<sup>1</sup> Screening Levels are developed using risk assessment guidance from the EPA Superfund program. These risk-based concentrations are derived from standardized equations combining exposure information assumptions with EPA toxicity data. These calculated screening levels are generic and not enforceable cleanup standards but provide a useful gauge of relative toxicity.

<sup>2</sup> Tap water screening levels differ from the IRIS drinking water concentrations because the tap water screening levels account for dermal, inhalation and ingestion exposure routes; age-adjust the intake rates for children and adults based on body weight; and time-adjust for exposure duration or days per year. The IRIS drinking water concentrations consider only the ingestion route, account only for adult-intake rates, and do not time-adjust for exposure duration or days per year.

## What detection and site characterization methods are available for RDX?

- ❖ RDX is commonly deposited in the environment as discrete particles with strongly heterogeneous spatial distributions. Unless precautions are taken, this variability causes highly variable soil data, which can lead to confusing or contradictory conclusions about the location and degree of contamination. As described in SW-846 Method 8330B, proper sample collection (using an incremental field sampling approach), sample processing (which includes grinding) and incremental subsampling are required to obtain reliable soil data (EPA 2006).
- ❖ RDX, manufactured in the United States using the Bachmann process at Holston AAP, contains octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) (also commonly known as octogen or High Melting Explosive) as a manufacturing impurity of RDX at a level of approximately 10 percent. Therefore, some experts recommend that sites potentially containing RDX or RDX-containing explosives fillers (such as Composition B) be analyzed for HMX (HSDB 2013; U.S. AEHA 1985).
- ❖ Both RDX and HMX are analytes included for EPA SW-846 Methods 8330 (high-performance liquid chromatography (HPLC) – ultraviolet (UV) detector) and 8095 (gas chromatography (GC)–electron capture detector [ECD]) (EPA 2007a, b).
- ❖ HPLC and high-resolution gas chromatography (HRGC) have been paired with several types of detectors, including mass spectrometry (MS), thermal energy analyzer (TEA), electrochemical detection (ED), ECD and UV detector to analyze for RDX and related contaminants (ATSDR 2012).
- ❖ EPA SW-846 Method 8330 is the most widely used analytical approach for detecting RDX in soil. The method specifies using HPLC with a UV detector. It has been used to detect RDX and some of its breakdown products at levels in the low ppb range in water, soil and sediment (EPA 2005, 2007b, 2012d).
- ❖ Another method commonly used is EPA SW-846 Method 8095, which employs the same sample processing steps as EPA SW-846 Method 8330, but uses capillary column GC - ECD for detection of explosives in water and soil (EPA 2005, 2007a, 2012d).
- ❖ EPA SW-846 Method 8321, which uses HPLC-MS, may be modified for the determination of RDX in soil. Since RDX is not a target analyte for this method and the sample processing steps are not appropriate for use with energetic compounds, this method is commonly modified for RDX to employ different sample processing steps, such as those identified in Method 8830 (EPA 2012d).
- ❖ Specific field screening methods for RDX include EPA SW-846 Method 4051 to detect RDX in soil by immunoassay and EPA SW-846 Method 8510 to detect RDX and HMX using a colorimetric screening procedure (U.S. Army 2009; USACE 2005).
- ❖ EPA Method 529 used solid phase extraction and capillary column GC and MS for the detection of RDX in drinking water (EPA 2002).
- ❖ Colorimetric methods generally detect broad classes of compounds such as nitroaromatics or nitramines. As a result, these methods are able to detect the presence of the target analytes and also respond to many other similar compounds. Immunoassay methods are more compound specific (EPA 2005).
- ❖ The EXPRAY is a simple colorimetric screening kit that can be used for qualitative tests for RDX and related compounds in soil. It is also useful for screening surfaces and unknown solids. The tool's detection limit is about 20 nanograms (EPA 2005; USACE 2001).
- ❖ Prototype biosensor methods for RDX have been field-tested and are emerging methods for explosives analysis in water (EPA 1999).
- ❖ Tested field-screening instruments for RDX include FAST 2000, which uses antibodies and fluorescence, and GC-IONSCAN, which uses ion mobility spectrometry (IMS) (EPA 2000a, b).

## What technologies are being used to treat RDX?

- ❖ Bioreactors, bioslurry treatments and passive subsurface biobarriers have proven successful in reducing RDX concentrations (CRREL 2006; EPA 2005; DoD ESTCP 2010).
- ❖ Composting has been successful in achieving cleanup goals for RDX in soil at field demonstrations (EPA 2005).
- ❖ In situ chemical remediation can also be used to treat RDX. Fenton oxidation and treatment with iron metal (FeO) has been used to remediate RDX-contaminated soil and water but has not been used as a stand-alone, full-scale treatment technology (EPA 2005; EPA NCER 2013).
- ❖ In a recent pilot-scale demonstration, in situ chemical reduction using buffered sodium hydrosulfite effectively reduced RDX concentrations in soil (Luo and others 2012).

## What technologies are being used to treat RDX? (continued)

- ❖ Phytoremediation of RDX-contaminated water and soil is being evaluated as a potential treatment technology (Lamichhane and others 2012; Panz and Miksch 2012).
- ❖ A recent study was conducted to evaluate the transformation of RDX in plant tissues. Research results indicated that the concentration of chlorophyll in leaf tissues affects RDX concentration in the plants. When the chlorophyll concentration is low, then RDX degrades quickly and does not accumulate (CRREL 2013).
- ❖ Other methods of treating waters contaminated with RDX include activated carbon, UV radiation and in situ bioremediation (ATSDR 2012).
- ❖ The Department of Defense's Strategic Environmental Research and Development Program (SERDP) is conducting a field-scale demonstration at the Umatilla Chemical Depot to assess the application of bioaugmentation to enhance RDX biodegradation in groundwater under aerobic conditions. The project is anticipated to be complete in 2015 (DoD SERDP 2012).

## Where can I find more information about RDX?

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## Where can I find more information about RDX? (continued)

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